

SECTION 3.0

SITE CHARACTERIZATION DATA

In comparison with a pump-and-treat system, a permeable barrier is a relatively permanent structure. Whereas, for a pump-and-treat system, locations of pumping wells, pumping rates, and above-ground treatment methods can be changed or modified as understanding of the site grows, a permeable barrier is difficult to relocate and change. Therefore, it is important to understand the site as well as possible before installing the barrier. The following aspects of the site are important to know:

- Groundwater flow system characteristics
- Organic composition of the groundwater
- Inorganic composition of the groundwater.

Because seasonal variations in such factors as flow and rainfall events could affect these site parameters, quarterly data collected over the period of 1 year would be desirable. Some parameters may be sampled more frequently or continuously for added certainty. However, at many sites, designers have to work with what is available. If data appear to be inadequate, it may be possible to do some additional characterization while collecting groundwater samples for laboratory treatability testing. Appendix A-1 contains an example of a site profile sheet (ETI, 1996) that has been used to determine the suitability of various sites for permeable barrier treatment and to establish treatability testing and modeling parameters.

3.1 GROUNDWATER FLOW SYSTEM CHARACTERISTICS

The requirements for groundwater flow system characterization include data on geologic and hydrologic parameters. In most cases, the needed information is available from previous studies conducted at the sites, such as the Remedial Investigation/Feasibility Study (RI/FS), Record of Decision (ROD) reports, and groundwater modeling reports. Sometimes, additional site-specific characterization may be needed to support the feasibility study, site selection, and design of the permeable barriers. The example preliminary site profile questionnaire (Appendix A-1) asks for brief data on site stratigraphy, soil types, depth of water, groundwater flow direction, groundwater velocity, hydraulic conductivity (K), porosity, depth to confining layer, and dimensions and depth of the dissolved plume. However, once the decision to implement the permeable barrier technology has been taken based on a preliminary assessment of site data, more detailed information on these and other parameters may be needed during the design phase of the process. Various aspects of the detailed site hydrogeologic characterization and their implications are discussed in Appendix A-2 and summarized below.

10.5 Site Background Information

General background information on the physical features of the site and groundwater is needed for initial assessments of the feasibility of a permeable barrier at the site candidate locations and additional site characterization, if necessary. Background information generally is available in existing documents, such as previous site characterization reports, aerial photographs, site maps, well logs, and quarterly monitoring reports. Surface and subsurface features that may impede the installation of an in situ barrier are identified.

3.1.2 Hydrostratigraphic Framework

The hydrostratigraphic framework involves the site-specific geologic and hydrologic data required to construct a conceptual understanding of groundwater flow at the site. This may include

information collected from previous reports, as well as new information collected specifically to evaluate and design a permeable barrier. The most significant data to be collected include variations in the depth, thickness, and water levels of different hydrostratigraphic units (HSUs). This is achieved by drilling and sampling several locations by conventional drilling or other techniques, such as cone penetrometer testing (CPT) or GeoProbe™. The number and locations of boreholes and samples required for the site heterogeneity assessment should be based on the scientific judgment of the on-site hydrogeologist and the availability of pre-existing data.

3.1.3 Hydrologic Parameter Estimation

Hydrologic or groundwater flow parameters are very important in permeable barrier design. The following parameters greatly influence the configuration and dimensions of the barrier installed and are discussed in more detail in Appendix A-2.

- Hydraulic conductivity (K)
- Porosity
- Hydraulic gradient
- Groundwater flow direction and velocity.

3.2 ORGANIC COMPOSITION OF THE GROUNDWATER

Information on the extent and type of chlorinated organics contamination is critical for the feasibility study, batch and column tests, permeable cell placement, design development, and performance monitoring. The presence and concentration of nonchlorinated organic compounds also may be of interest in selecting an appropriate reactive medium or treatment scheme.

3.2.1 Organic Contaminant Spatial Distribution

This section deals with the spatial distribution of chlorinated organics contamination. In many cases, several different contaminant plumes are present at a single site. In general, the three-dimensional distribution of each contaminant plume at the site needs to be delineated so that the permeable barrier can be appropriately sized to capture it. This includes the identification of the contaminated aquifer(s), the depth and width of the plume(s), the average and maximum concentration, and the rate of plume movement. In addition, it is important to characterize the significant processes that affect the spread of contamination in the subsurface at the site. These may include the effects of adsorption/retardation, chemical reactions, dispersion, and vertical plume movement due to fluid density effects.

In many cases, some of the required data already would be available from the RI/FS, ROD, Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI), or routine monitoring reports from the site. Therefore, no new data may need to be acquired for plume characterization at these sites. Instead, a careful review of existing reports should be conducted and new data should be collected only if significant data gaps are found or if the preexisting data are out of date or inadequate. If needed, groundwater samples can be collected to fill data gaps or to improve sampling density in areas of particular interest or for specific analytes. Unless available from the recent site reports, the compiled data should be plotted on isopleth maps and on the cross-section profiles to evaluate the lateral and vertical extent of the plumes.

The width of the contaminant plume can be determined from the isopleth maps of concentration. If sufficient data are available, the maps may also reveal the potential source zones for the contaminants

and the existence of preferential pathways for contaminant migration along which the contaminants have advanced. The plume maps can also be used to identify a potential location and design for the permeable barrier installation. In most cases, the barrier is installed near the downgradient end of the plume. However, several factors may lead to the installation of barriers within the plumes. For example, barriers may have to be installed at the property boundary, even if a portion of the plume already has moved past the property boundary, if site access to the edge of the plume is difficult. Sometimes the barrier may be located in the proximity of the highest concentration parts of the plume to expedite the remediation of the most contaminated areas. Such a location may be required for slow moving plumes. Other measures may be required in such cases to address the remaining portion of the plume.

The design of the permeable barrier is controlled partly by contaminant distribution. In most cases, the barrier should be installed to capture the entire plume width and depth. This may be done either by installing the permeable barrier across the entire width or by installing a small reactive cell flanked by funnel walls. These design considerations for the permeable barriers are further discussed in the modeling information in Section 5.1.

3.2.2 Groundwater Sampling for Volatile Organic Compounds (VOCs)

Groundwater sampling provides essential information on water movement, contaminant levels, and inorganic chemistry and geochemistry needed to understand and model the performance of the reactive cell.

Proper quality assurance (QA) procedures, as described in EPA SW-846, should be followed during sampling to ensure valid data. Zero headspace should be ensured prior to sealing the sample containers. Sample containers should be labeled, logged, and stored at approximately 4°C while they are being transferred under chain-of-custody protocol to an analytical laboratory for analysis. Analysis must be completed prior to expiration of recommended holding times. Field duplicates, field blanks, and trip blanks are commonly used quality control (QC) samples that aid data quality evaluation.

3.2.3 Analytical Methods for VOCs

This section briefly describes the methods used for analysis of groundwater to meet the essential requirements of a site characterization study. Volatile organic compounds (VOCs) in groundwater samples can be analyzed by EPA Method 8240 (*Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)*, EPA SW-846, Update II, September 1994) or EPA Method 8260 (similar to Method 8240, but uses capillary column) in conjunction with EPA Method 624 (*Purgeables*, EPA SW-846, July 1991). Method 624 is a sample preparation and extraction procedure for analysis of VOCs by a purge-and-trap apparatus. This technique can be used for most VOCs that have boiling points below 200°C and are insoluble or slightly soluble in water. **Volatile, water-soluble compounds can be included** in this analytical technique; however, quantitation limits by gas chromatography (GC) are generally higher because of poor purging efficiency.

QA involves the use of blanks, duplicates, and matrix spikes to ensure laboratory data quality. The accuracy and precision of Method 8240 or Method 8260 are related to the concentration of the analyte in the investigative sample and are essentially independent of the sample matrix. Linear equations pertaining to accuracy and precision for a few compounds are discussed in the method descriptions. **The estimated quantitation limit (EQL) for individual compounds is approximately 5 µg/L in groundwater samples.** EQLs are proportionally higher for sample extracts and samples that require dilution or reduced sample size to avoid saturation of the detector.

3.3 INORGANIC COMPOSITION OF THE GROUNDWATER

Monitoring of inorganic field parameters such as pH, redox potential (Eh), and dissolved oxygen (DO) in the groundwater is very important because they can be used to determine whether conditions at the site are conducive to formation of inorganic precipitates. These three groundwater field parameters should be monitored over at least 1 year to evaluate seasonal fluctuations. Similarly, chemical species that may react with the medium in the barrier include Ca, Fe, Mg, Mn, Al, Ba, Cl, F, SO_4^{2-} and HCO_3^- (alkalinity); significant redox-sensitive elements include Fe, C, S, and N. For example, iron in solution may be in the ferrous [Fe(II)] state or ferric [Fe(III)] state, and organic carbon as humic or fulvic substances may be reduced to methane in the reactive cell. Sulfate [S(VI)] may be reduced to bisulfide [S(-II)] and nitrate may be reduced to nitrogen gas [N(O)] or ammonia [N(-3)] if conditions are conducive. Bromide is measured mainly because it potentially can be used as a tracer during performance monitoring of the barrier.

3.3.1 Sampling and Analysis of Field Parameters

The primary purpose of taking field parameter measurements is to monitor aquifer conditions that can affect the performance of the reactive wall. Therefore, the water level, temperature (T), pH, Eh, and DO should be measured at designated monitoring wells. To obtain accurate readings, T, pH, and Eh, should be measured using the most appropriate method available to provide representative values. Typical devices include a downhole probe with multiple sensors and a flowthrough cell shielded by an inert gas. Other parameters, such as specific conductance, turbidity, and salinity of a groundwater sample can be measured ex situ, if required, using appropriate field instruments. Table 3-1 lists the field parameters and corresponding analysis methods.

**Table 3-1. Requirements for Field Parameters and Inorganic Analytes
(based on EPA SW-846)**

Analyte or Parameter	Analysis Method	Sample Volume	Storage Container	Preservation	Sample Holding Time
<i>Field Parameters</i>					
Water Level	In-Hole Probe	None	None	None	None
pH	In-Hole Probe	None	None	None	None
Groundwater Temperature	In-Hole Probe	None	None	None	None
Redox Potential	In-Hole Probe	None	None	None	None
Dissolved Oxygen	In-Hole Probe	None	None	None	None
Specific Conductance	Field Instrument	None	None	None	None
Turbidity	Field Instrument	None	None	None	None
Salinity	Field Instrument	None	None	None	None
<i>Inorganic Analytes</i>					
Metals (K, Na, Ca, Mg, Fe, Al, Mn, Ba)	200.7	100 mL (all)	Polyethylene	Filter ^(a) , 4°C, pH<2 (HNO ₃)	180 days
Anions (NO ₃ , SO ₄ , Cl, Br, F)	300.0	100 mL (all)	Polyethylene (all)	4°C (all)	28 days (48 hours for NO ₃)
Alkalinity	310.1	100 mL	Polyethylene	–	14 days
Other					
TDS, TSS	160.2, 160.1	100 mL	Polyethylene	4°C	7 days
TOC, DOC	415.1	40 mL	Glass	4°C, pH <2 (H ₂ SO ₄)	7 days

(a) 0.45 μm pore size.

3.3.2 Sampling and Analysis for Inorganic Chemical Parameters

Inorganic analytes should be measured because they provide valuable information about the demands on the reactive medium itself. Samples should be collected from each monitoring point for laboratory analysis as indicated in Table 3-1. Samples should be filtered (for cations only) and preserved immediately after collection. The typical filter pore size for cation analysis is 0.45 μm ; however, filters of different pore size may be used from time to time for comparison. In addition, several samples should be collected and preserved without filtering to determine the content in the suspended matter. Total dissolved solids (TDS) and total suspended solids (TSS) should be determined from filtered and unfiltered samples, respectively. QA procedures include the use of blanks, duplicates, and matrix spikes to ensure data quality.